20 March 1970

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

3674

DIRECTION FINDING EQUIPMENT, GYROSCOPES

1. OBJECTIVE

The objective of this Materiel Test Procedure is to describe the engineering tests required to determine the technical performance and safety characteristics of gyro-stabilized direction finding equipment relative to the requirements of applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other applicable requirements and documentation, and determining their suitability for an intended use.

2. BACKGROUND

Modern military aircraft operations require the use of precise and reliable navigational aids. Gyro-stabilized systems for navigation are essential to operations in remote areas where ground-based navigation aids are inadequate or non-existent. Consciousness of one's location is of paramount importance to conduct a tactical operation. It is not always possible to rely on eyesight and reference points in one's surroundings. Weather conditions may prevail such that visibility may be limited to a degree that total reliance must be placed on instruments to obtain an accurate "fix" of one's geographic location or to determine the direction of travel, whether it's on the surface or airborne.

A military maneuver may very well depend on the precision of such instrumentation.

When such equipment is used for military aircraft, engineering tests must be performed to determine the degree of compliance with specified technical requirements and permit evaluation of suitability and safety of the item for service test.

3. REQUIRED EQUIPMENT

a. Environmental test facility.
b. Voltmeter (VTVM).
c. Ammeter.
d. Oscilloscope.
e. Specified gyroscope test tables and test kits.

4. REFERENCES

A. Cochin, Ira, Analysis and Design of the Gyroscope for Inertial Guidance, John Wiley and Sons, 1963.
B. Pitman, G. R., et al, Inertial Guidance, John Wiley & Sons, 1962.
C. Savet, P. H., et al, Gyroscopes: Theory and Design, McGraw-Hill, 1961.

D. EETC Reports on Gyro Terminology and Test Instructions (6), Aerospace Industries Association of America, Inc. Washington, D. C., 1962-1965.
E. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
F. AMCR 385-12, Verification of Safety of Materiel from Development Through Testing, Production, and Supply to Disposition.
G. MTP 6-2-120, Heading Reference System.
H. MTP 6-2-500, Physical Characteristics.
I. MTP 6-2-502, Human Factors Engineering.
J. MTP 6-2-503, Reliability.
K. MTP 6-2-504, Design for Maintainability.
L. MTP 6-2-507, Safety.
M. MTP 6-2-530, Altitude and Temperature-Altitude Tests.
N. MTP 6-2-531, Temperature Tests.
O. MTP 6-2-534, Humidity Tests.
P. MTP 6-2-536, Salt Fog Tests.
Q. MTP 6-2-537, Dust Tests.
R. MTP 6-2-539, Immersion Tests.
S. MTP 6-2-540, Vibration Tests.
T. MTP 6-2-541, Shock Tests.

5. SCOPE

5.1 SUMMARY

This materiel test procedure outlines a series of engineering tests which will allow an estimate to be made of the suitability of the equipment tested to meet the operational need.

a. Voltage Breakdown - the objective of this subtest is to determine if the test item meets the insulation requirements.
b. Leak Test - the objective of this subtest is to determine if the test item is leak proof.
c. Drift Test - the objective of this subtest is to determine the apparent drift of the test item due to the earth's rotation.
d. Balance Test - the objective of this subtest is to determine the balance of the gyro.
e. Precession Rate Test - the objective of this subtest is to determine the average precession rate of the gyro.
f. Leveling Pickoff Signal Gradient Test - the objective of this subtest is to determine the voltage induced by the coils when the spin axis is tilted.
g. Leveling Rate Test - the objective of this subtest is to determine the average rate of leveling of the gyro.
h. Scale Error Test - the objective of this subtest is to determine the error in readings between the turntable heading and the indicator heading.

NOTE: The common engineering tests referenced in paragraph 4 provide the test procedures required to test the commodity

involved. The test procedures have not been repeated in this MTP, but the applicable portions of the common engineering test MTP's will be applied.

5.2 LIMITATIONS

This materiel test procedure is limited to tests of the directional gyro unit. The amplifier has not been considered here.

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Upon establishing the scheduled availability of the test item, coordinate the availability of the following:

1) Engineering safety release or other safety statement.
2) Maintenance support facilities, spare parts, and personnel.
3) Equipment, special facilities, and instrumentation.

b. Record the nomenclature, serial number(s), manufacturer's name and function of item under test.

c. Record the nomenclature, serial number, accuracy, tolerances, calibration requirements, and last day of calibration of the electronic test equipment.

d. Assure that test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in Qualitative Materiel Requirements (QMR's), Small Development Requirements (SDR's), and Technical Characteristics (TC's).

e. Assure that instructional material issued with the test item by the manufacturer, contractor, or government shall be readily available for reference by test personnel. Test personnel shall be familiar with the contents of such documents prior to start of tests.

f. Prepare adequate safety precautions to provide safety for personnel and equipment, and ensure that all safety SOP's are observed throughout the test and that the item has successfully completed MTP 6-2-507, Safety.

g. Assure that the test item is thoroughly inspected for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent fragile parts, and corroded plugs and jacks. All defects shall be noted and corrected before proceeding with the test.

6.2 TEST CONDUCT

6.2.1 Voltage Breakdown

a. Apply the maximum specified voltages between the input pins (tied together) and ground.

b. Hold the voltage level for approximately five seconds.

c. If sparking occurs, apply the following measures:

1) Locate source of breakdown and discontinue test immediately.
2) Correct and note the deficiency (if authorized) and repeat the test.

6.2.2 Leak Test

6.2.2.1 Preparation for Leak Test

Obtain a container which:

a. Is large enough for gyro to be placed inside.
b. Can be filled with water to cover the test item to a depth of two inches.
c. Can be evacuated to a vacuum of approximately 2.5 inches of mercury.
d. Has a clear top to enable the test officer to monitor the test visually.
e. Has inlets for water and connection to vacuum pump, both above "water line." (See Figure 1.)

6.2.2.2 Conduct of Leak Test

a. Place gyro in container and seal it.
b. Partially evacuate the air from the chamber and commence filling with water.
c. Evacuate chamber to an approximate pressure of 2.5 inches of mercury while filling with water to approximately 2 inches above the test item.
d. Observe the test item while immersed (120 minutes ± 5 minutes). and check for bubbles coming from interior of test item.

6.2.3 Drift Test

6.2.3.1 Preparation for Drift Test

a. Mount gyro on test stand and clamp into position.
b. Plug in cable from gyro into test equipment.
c. Adjust switches to specified positions (gyro motor ON, power ON, etc.).
d. Adjust voltage and phase to specified levels.
e. Allow 30 minute warmup time.

6.2.3.2 Conduct of Test

a. Release turntable clamp.
b. Rotate test stand until indicator reads zero degrees and clamp the turntable.
c. Unclamp the turntable azimuth scale and rotate until the scale zero lines up with the vernier zero, and reclamp the scale.

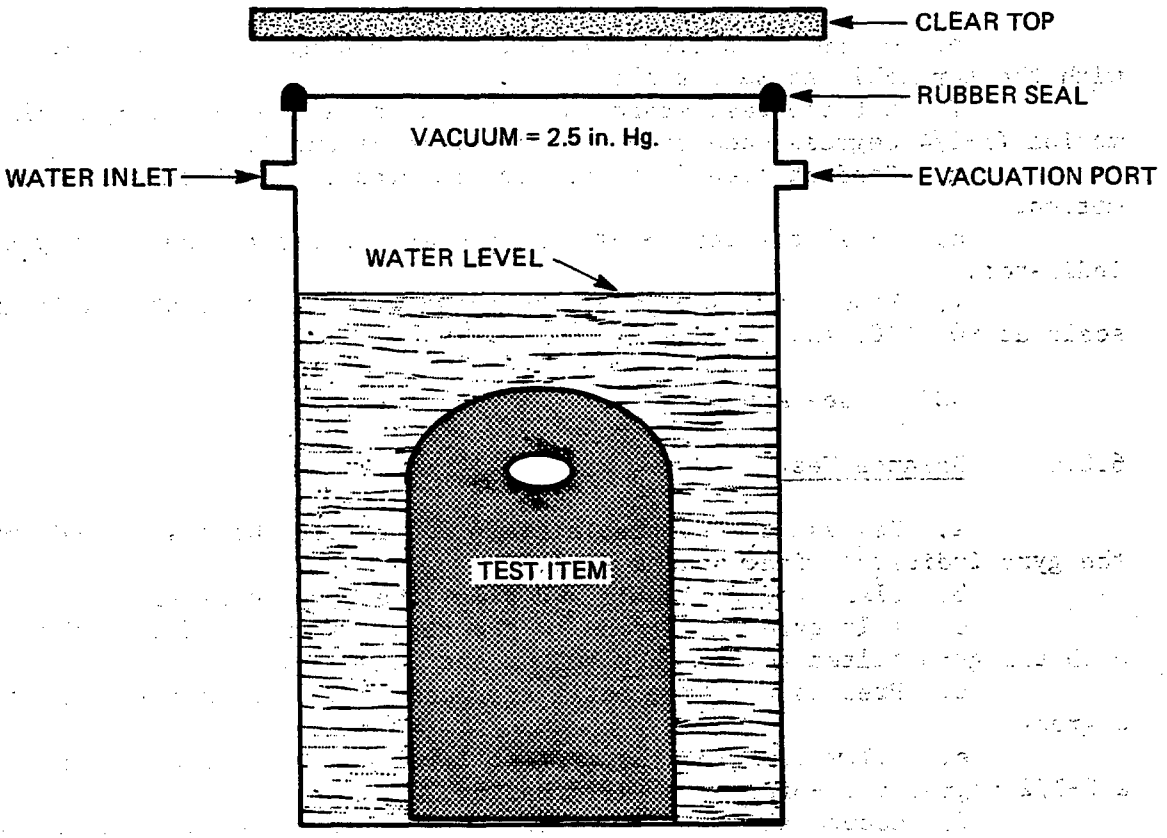

Figure 1. Leak Test Setup

NOTE: At this point, verify gyro leveling by observing the level pickoff voltage. The voltage reading should be the specified minimum.

d. Precess the gyro by adjusting the controls on the test equipment until the indicator heading agrees with the turntable azimuth scale reading.

NOTE: Follow manufacturer's instructions for the given gyro.

e. Switch the current OFF when the heading of the indicator agrees with the turntable azimuth scale.

f. Set the test stand for a 2-1/2 degree roll-pitch-yaw (RPY) motion (1-1/4 degrees each side of the reference axis).

g. Conduct step f, above, for 30 minutes and then halt the RPY motion.

h. Level the test stand and prepare to record the heading of the indicator.

i. Repeat the same steps as above with the turntable azimuth scale at 90, 180, and 270 degrees.

NOTE: See Appendix A.

6.2.4 Balance Test

a. Release the turntable clamp and rotate the test stand until the gyro indicator window faces east.

b. Clamp the turntable and allow the gyro to level.

c. Tilt gyro 15 degrees to the right as viewed facing the window with the gyro tilted toward TRUE NORTH, not magnetic.

d. Precess the gyro until the heading on the indicator is zero degrees.

e. Allow time for the gyro to level and set the test stand for a 2-1/2 degree roll-pitch-yaw (RPY) motion.

f. Accurately time the test for 30 minutes and then halt the RPY motion.

g. Level the test stand (not the gyro which remains tilted 15 degrees to the right), and note the heading of the indicator.

h. Repeat the test with the gyro tilted 15 degrees to the left.

i. Correct the change in the heading of the indicator.

6.2.5 Precession Rate Test

6.2.5.1 North Latitude Coils

a. Release the turntable clamp and rotate the test stand until the turntable azimuth scale indicates zero degrees and then reclamp the turntable.

b. Precess the gyro until the heading shown on the master indicator is zero degrees.

c. Set the test stand for a 2-1/2 degree roll-pitch-yaw (RPY) motion.

d. Adjust current in the coil (to the level specified by the manufacturer) to precess the gyro in such a direction as to increase the heading on the indicator.

e. Halt the RPY motion after a 20 minute test run and level the test stand.

f. Note the change in heading indication on the indicator.

g. Reset the test stand for a 2-1/2 degree RPY.

h. Adjust the current as in step d, but in the opposite direction so as to decrease the heading.

i. Halt the RPY motion after 20 minutes and level the test stand.

j. Note the change in heading.

k. Compute the average precession.

6.2.5.2 South Latitude Coils

a. Precess the gyro until the indicator heading is zero degrees.

b. Repeat the precession rate test as for the North Latitude Coils and apply the same limits.

6.2.6 Leveling Pickoff Signal Gradient Test

a. Release the turntable clamp and position the gyro to a zero degree heading as appears on the gyro window.

b. Clamp the turntable and precess the gyro until the heading on the indicator is zero degrees.

c. Release the clamps and set the turntable azimuth scale to zero and allow the gyro to level.

d. Release the clamps on the tilt axis of the fixture.

e. Connect the VTVM to the output of the pickoff coils.

f. Tilt the fixture about the zero position until the best electrical null is observed on the VTVM.

g. Clamp the fixture and bring the tilt scale zero to correspond with the vernier zero.

h. Tilt the gyro 80 degrees to the right and note the pickoff voltage.

i. Tilt the gyro 80 degrees to the left and note the pickoff voltage.

j. Repeat steps h and i at right and left tilt angles of 30 and 10 degrees and note the data in preparation for the following test.

6.2.7 Leveling Rate Test

a. Return fixture to zero degree tilt position and allow time for leveling.

b. Tilt the gyro 30 degrees to the right.

c. Stop the test when the gyro is within 10 degrees of being level and the VTVM indication is the same as noted for a 10 degree tilt angle.

d. Note the time required to level.

e. Repeat the test for gyro tilt of 30 degrees to the left.

6.2.8 Scale Error Test

a. Precess the gyro so that the heading shown on the indicator is zero degrees and the turntable azimuth scale reads zero degrees.

b. Unclamp the turntable and rotate clockwise until the azimuth scale indicates approximately 30 degrees.

c. Note the readings on the turntable azimuth scale and the indicator.

d. Rotate the turntable to approximately 60 degrees and note the turntable azimuth scale reading.

e. Repeat steps c and d in 30 degree increments to include 330 degrees.

f. Set the turntable at exactly 360 degrees.

g. Note the final indicator heading and the total elapsed time.

h. Correct the indicator headings for effect of earth's rotation (see Appendix A) and for random gyro drift over the test interval.

i. Calculate the difference between the indicator headings with the turntable at zero degrees (before test) and at 360 degrees (after the test). This represents the total drift of the gyro over the total time taken for the test.

j. Correct the indicator heading by adding:

1) 1/12 of the total drift to the 30° heading.
2) 2/12 of the total drift to the 60° heading.
3) 3/12 of the total drift to the 90° heading, etc.

k. Determine the scale error at each 30 degree scale point by taking the difference between the turntable heading as shown on the azimuth scale and the indicator heading as corrected above.

6.3 TEST DATA

6.3.1 Preparation for Test

Data to be recorded prior to testing shall include but not be limited to:

a. Nomenclature, serial number(s), manufacturer's name, and function of the item(s) under test.

b. Nomenclature, serial number, accuracy tolerance, calibration requirements, and last date calibrated of the test equipment selected for the tests.

6.3.2 Test Conduct

Data to be recorded in addition to specific instructions listed below for each subtest shall include:

a. A block diagram of the test setup employed in each specified

test. The block diagram shall identify by model and serial number, all test equipment and interconnections (cable lengths, connectors, attenuators, etc.) and indicate control and dial settings where necessary.

b. Photographs or motion pictures (black and white or color), sketches, charts, graphs, or other pictorial or graphic presentation which will support test results or conclusions.

c. An engineering logbook containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data.

6.3.2.1 Voltage Breakdown

a. Identify and record the location of the voltage breakdown, if any.

b. Record procedures used to correct deficiency, when required.

6.3.2.2 Leak Test

a. Record reading of vacuum gauge.
b. Record depth of water.
c. Record location of leaks, if any.

6.3.2.3 Drift Test

a. Record the heading of the indicator after the 30 minute test for each of the turntable settings.

b. Correct each reading for effect of the earth's rotation (see Appendix A).

6.3.2.4 Balance Test

a. Record the heading of the indicator.

b. Record the readings corrected for the effect of the earth's rotation.

6.3.2.5 Precession Rate Test

a. Record the change in heading indication obtained in step 6.2.5.1f.

b. Record the change in heading indication obtained in step 6.2.5.1j.

c. Compute the precession rates in degrees per minute by dividing the angular changes in a and b (above), by 20.

d. Add the two precession rates and divide by two to obtain the average precession rates.

e. Record the average rates.

6.3.2.6 Leveling Pickoff Signal Gradient Test

a. Record the voltage observed in step 6.2.6h.

b. Record the voltage observed in step 6.2.6i.
c. Record the data for each setting specified in step 6.2.6j.

6.3.2.7 Leveling Rate Test

a. Record the time interval observed in step 6.2.7d.
b. Record the time interval for every other setting required in step 6.2.7e.
c. Compute and record the average of the time intervals observed.

6.3.2.8 Scale Error Test

a. Record the headings observed in step 6.2.8c.
b. Record the heading observed in step 6.2.8d.
c. Record every other heading observed in step 6.2.8.e.
d. Record the final indicator heading and the total elapsed time.
e. Record the headings corrected for the effect of the earth's rotation.
f. Record the scale error obtained in step 6.2.8k.

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general, consist of organizing, marking for correlation and identification, and grouping of the test data according to subtest title. Test criteria or test item specifications shall be noted on the test data presentation to facilitate analysis and comparison. Where necessary, test data measurements shall be converted to be compatible with units given by test criteria or specifications. Specific instructions for the reduction and presentation of individual subtest data are outlined in the succeeding paragraphs.

6.4.1 Voltage Breakdown

a. If breakdown occurs, identify the location on schematic diagram.
b. Catalog the deficiencies and measures taken to correct the deficiencies.

6.4.2 Leak Test

Present the results of the leak test in statement form.

6.4.3 Drift Test

a. Tabulate the drift at each heading after correcting for the effect of the earth's rotation.
b. Compare the corrected readings with the specified limits.

6.4.4 Balance Test

a. Tabulate the corrected readings of each heading and for each tilt angle.

b. Compare the corrected readings with the specified limits.

6.4.5 Precession Rate Test

a. Tabulate all precession rates before and after averaging.
b. Compare average rates with those specified.
c. Present the acceptable limits in degrees per minute.

6.4.6 Leveling Pickoff Signal Gradient Test

a. Tabulate the voltage levels for each tilt angle.
b. Compare the measured voltage levels with the limits required.

6.4.7 Leveling Rate Test

a. Tabulate the time intervals recorded and present each with its corresponding setting.
b. Compare each computed average with the limits specified with the test unit.

6.4.8 Scale Error Test

a. Tabulate the scale error computed for each of the headings.
b. Present the sum of the magnitudes of the most positive and the most negative errors.
c. Compare the sums presented in above step with the limits specified.

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APPENDIX A

EFFECT OF EARTH'S ROTATION

A gyro that maintains a fixed heading in azimuth is subject to an apparent drift due to the rotation of the earth. This apparent drift is greatest (15 degrees per hour) at the North and South Poles, and is zero at the Equator. The direction of drift is such that the gimbal of the gyro appears to rotate clockwise (decreasing the heading indication) in the Northern Hemisphere, and in the opposite direction (increasing the heading indication) in the Southern Hemisphere. The drift rate depends on the latitude at which the gyro is located and is given by:

Drift rate (Degrees/hour = 15 (Sine of λ)
where λ is the latitude at the test location.

When the gyro is tilted to the north 15 degrees, as in the balance test, the effect is the same as if the test location were 15 degrees closer to the North Pole; thus the drift rate is given by:

Drift Rate (Degrees/hour) = 15 Sine$[(\lambda + 15^{o})]$
in the Northern Hemisphere, or

Drift Rate (Degrees/hour) = 15 Sine$[(\lambda - 15^{o})]$
in the Southern Hemisphere.

The effect of tilting the gyro to the south is opposite; that is, it is equivalent to moving the test location 15 degrees nearer to the South Pole.

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13. ABSTRACT

This Engineering Test Procedure describes test methods and techniques for evaluating the technical performance and characteristics of Direction Finding Equipment (Gyro-stabilized Type). The evaluation is related to criteria expressed in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate design requirements and specifications.

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